ABSTRACT

Accurate prediction of hardness at any desired location and optimisation of process parameters for a specimen subjected to laser transformation hardening process, is the prime objective of the present investigation. The numerical and experimental investigations presented in this thesis are concerned with the prediction and determination of microstructure and microhardness for steel specimen. As the commonly used one-dimensional models have limitations with respect to the workpiece size, beam mode, variable thermophysical properties, boundary conditions and the like, a three-dimensional approach is followed in the present work.

A Finite Difference Implicit Splitting Scheme is used to solve the three-dimensional transient heat conduction and carbon diffusion process. The scheme is unconditionally stable and requires less computational time. Temporal Thermal Profiles (TTPs) at various locations in the workpiece, are first obtained using the three dimensional thermal model. These TTPs are considered as input to the three dimensional carbon diffusion model to determine the carbon concentration distribution and the volume fraction of austenite at the end of dwell time of the TTP.

Using the informations such as cooling rate and cooling time from the TTP, volume fraction of austenite from carbon diffusion model, and composition of the specimen, the value of hardness at a desired location in the specimen is estimated. The analysis is extended to obtain a set of optimum process parameters for maximum hardness. It is found that there exists a critical value of power density where hardness value reaches the peak, and above that value the hardness decreases drastically.

Finally a nomogram is presented to determine graphically the depth of hardness and hardness value for different sets of process parameters.

Experiments are carried out on three different grades of carbon steel specimens (C30, C40 and C45) using a 5 kW continuous wave CO_2 laser. Variation of hardness and microstructure at different process parameters are presented. The most hardended structure achievable for different grades of steels by laser heat treatment process are also reported. Finally the theoretically predicted hardness values are compared with the experimental data and are found to be in agreement within 10%.

Keywords: **Laser Transformation Hardening, Implicit Splitting Method, Temporal Thermal Profile, Thermal Model, Carbon Diffusion Model.**